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Technical Report

FOAMGLAS INSULATION FOR BURIED HOT PIPES

June 1966

NAVAL FACILITIES ENGINEERING COMMAND

U. S. NAVAL CIVIL ENGINEERING LABORATORY

Port Hueneme, California

FOAMGLAS INSULATION FOR BURIED HOT PIPES

Technical Report R-451

Y-F020-02-02-002

by

John M. Stephenson

ABSTRACT

To determine if Foamglas is reliable for insulating and protecting buried hot pipes in direct contact with the soil, BuDocks requested NCEL to evaluate this waterproof insulating material [Federal Specification (HH-I-551)]. A preliminary investigation disclosed that Foamglas was being used successfully by a number of organizations to protect pipes in dry soils. A more extensive investigation, which included examination of Foamglas-insulated pipes in situ and examination of samples of soils and Foamglas, disclosed: (1) the vapor barrier on the Foamglas was frequently broken, allowing moisture to penetrate the Foamglas insulation, (2) Foamglas absorbs more water (as much as 7.9% by volume) than had been reported, and (3) failure of vapor barrier and insulating material to prevent water intrusion permitted pipe corrosion, heat loss, and sometimes disintegration of the Foamglas. On the basis of these investigations it was concluded that Foamglas is not suitable for insulating pipes below the water table or in wet soils.

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INTRODUCTION

The design of underground hot piping systems has been a source of problems for many years. Heavy industry has generally avoided the problems by locating pipes above ground, whereas commercial firms in urban areas usually prefer the expensive procedure of building walk-in tunnels. The U. S. Navy has for aesthetic reasons installed most pipes underground, but walk-in tunnels are seldom used because of high cost and high water tables. These restrictions and the lack of suitable waterproof insulating material have forced the Navy to narrow its specifications to metal or asbestos-cement conduit for all installations subject to flooding (type A soil conditions). Unfortunately, the history of use of conduits shows many failures and expensive replacements; consequently, BuDocks has been searching for improvements to conduit systems and for new methods and materials. With respect to the latter, BuDocks requested that NCEL investigate the use of Foamglas, a material which qualifies under Federal Specification (HH-I-551) as a waterproof insulation and which has been widely and successfully used for above-ground installations.

Foamglas is a rigid cellular glass product manufactured by the Pittsburgh Corning Corp., Pittsburgh, Pennsylvania. In its manufacture, glass is treated in a patented process to form millions of small cells filled with air. Foamglas pipeline insulation is prepared by machining blocks of Foamglas into half round or segmental sections of various thicknesses. These sections, which are 18 to 24 inches long, are fitted over the pipe and banded in place. The insulation is then coated with various glass fabric tapes and cold applied mastics to provide a vapor barrier.

The program to carry out the investigation of Foamglas for underground use consisted of preliminary studies by NCEL and final studies by the Harco Corporation under Navy contract.

This report summarizes the highlights of all parts of the investigation and presents conclusions and recommendations based on the overall findings.

PRELIMINARY INVESTIGATION

Preliminary work by NCEL consisted of on-site visits to eight installations in California, and a telephone survey of 23 users of Foamglas insulation throughout the country.

On-Site Visits

The first on-site visit made by NCEL was to witness the installation of a new, Foamglas-insulated steampipe at the U. S. Naval Shipyard, San Francisco, California. The purpose of the installation was to evaluate the performance of Foamglas, and the on-site visit was made to observe the installation techniques. As a result of this visit, NCEL issued Technical Note N-467 (Reference 1), which made several recommendations on reducing the cost of installing Foamglas and suggested a change in the design of expansion loops. It was noted in the report that the effectiveness of the vapor barrier could not be checked at this site because the water table is below the pipe most of the time.

On-site visits were later made to seven California locations listed below:

International Business Machines, San Jose, California.

U. S. Navy, Treasure Island, California.

Ventura County School System, Thousand Oaks, California.

Orange County School System, Huntington Beach, California.

San Diego County School System, Fallbrook, California.

City of San Diego School System, San Diego, California.

Donald Sharp Memorial Hospital, San Diego, California.

At each site, information was obtained relative to the date of installation, type of service, pipe size, temperature of heating medium, type of soil, water table, and cost of installation. Detailed information on this survey is given in Reference 2. The results indicated that Foamglas with a suitable joint treatment, wrapping, and coating had performed satisfactorily for direct burial application above the water table. However, the acceptability of Foamglas for unrestricted use was uncertain at this time because insufficient data were available on the performance of Foamglas below the water table.

Telephone Survey

In making the telephone survey, contact was made with operating and maintenance personnel of 23 users of Foamglas-covered piping. Questions were asked pertaining to the physical characteristics of the heating pipe system, maintenance problems, soil moisture, and depth of water table. Detailed results of this survey are given in Appendix A. Although the results of the survey were inconclusive because most of the installations were in dry soil, they did reveal that Foamglas has been widely used — including one case where it had been installed for 16 years without failure.

Discussion of Results

The results from NCEL's preliminary work led to the conclusion that Foamglas was being successfully used in dry soil and had potential for wet soil; but before the investigation could be considered conclusive, more performance data were required for systems installed below the water table. To obtain such data an extensive survey was planned which would concentrate on the following factors:

1. Systems installed for 5 years or more
2. Systems installed below the water table or subject to flooding
3. Methods of installation
4. Corrosivity of the soil

FINAL INVESTIGATION

In June 1965 a contract was given to the Harco Corporation, Hawthorne, California, to conduct an investigation to be done in three phases. Under Phase I a list of Foamglas installations was to be compiled. Under Phase II, detailed information on pipelines was to be obtained. Under Phase III, a field inspection of selected pipelines was to be carried out with representatives of the contracting firm and NCEL in attendance.

All work under the contract was completed in November 1965 and the results of the three phases were reported by the contractor in References 3, 4, 5, and 6.

Phase I

Procedures. To identify a significant number of known Foamglas users, and firms likely to use this material, the contractor held interviews with representatives of the manufacturers of Foamglas and competitive products, Foamglas distributor contractors, the National District Heating Association, large district heating owners, and consulting engineers.

After obtaining lists of owners of Foamglas-covered pipelines, a telephone survey was conducted. A complete listing of the places contacted is given in Appendix B.

The following is a tabulation of the results of the Phase I survey:

Age Category	Number of Installations	Installations With Maintenance Problems	
		Number	%
0 - 5 yrs old	26	4	15
5 - 10 yrs old	32	17	53

Results and Discussion. From the interviews it was determined that Foamglas has been used far more extensively in the southeastern and southwestern parts of the United States than in other parts of the country. Furthermore, examination of Appendix B indicates that the primary users of Foamglas for covering underground heating pipes are the public school systems, colleges, and universities. The advantages in aesthetic appeal of using concealed pipelines and the favorable cost of Foamglas-covered buried heating pipelines in comparison with other underground systems appear to be factors determining use by schools. The data indicate that some Foamglas installations had operated very well for several years with no problems, while other Foamglas installations had many problems.

Of particular note are results reported at Tulane University, New Orleans, Louisiana, where a 100-foot-long test system of Foamglas was installed under water on hot pipe. The test system was installed to simulate the high water table which exists at Tulane. It is reported that moisture penetrated to the pipeline, converted to steam, and blew off the insulation.

Phase II

Procedures. Under Phase II, detailed information was obtained on six installations which are more than 5 years old and which are buried in wet ground. The six installations selected were:

Site 1	Municipality of Metropolitan Seattle Seattle, Washington	Hot Water System Installed 1958
Site 2	St. Thomas Aquinas High School St. Louis, Missouri	Hot Water System Installed 1957-58
Site 3	Ochsner Foundation Hospital New Orleans, Louisiana	Steam System Installed 1958
Site 4	Calhoun Falls High School Abbeville County School Dist. #60 Abbeville, South Carolina	Steam System Installed 1958

Site 5	Northern States Power Company Grand Forks, North Dakota	Steam System Installed 1954
Site 6	Duluth Steam Company Duluth, Minnesota	Steam System Installed 1949

Results and Discussion. At Sites 1 and 2, both systems carry hot water and are approximately the same age. At Site 1 in Seattle, the soil is wet but relatively noncorrosive whereas at Site 2 in St. Louis the soil is wet and very corrosive.

At Sites 3 and 4 both systems carry steam, are approximately the same age, and are installed in wet soil, moderately to relatively corrosive. Both of these systems have had extensive maintenance problems. It is noted that maintenance problems associated with these two steam systems existed for approximately the entire life of the pipelines and involved heat loss rather than pipe corrosion.

At Sites 5 and 6 both systems are for commercial steam distribution, and are located under city streets in relatively dry, noncorrosive soil. These two systems range in age from 11 to 16 years and neither has had maintenance problems. At Site 5 the system is surrounded with 4 inches of coarse gravel and at Site 6 the system is encased with 4 inches of concrete.

Phase III

Procedures. In the final phase of the work, firsthand information was obtained through excavation and visual examination of several pipelines. The following sites were selected for these inspections:

Site 1	Seattle, Washington; Municipality of Metropolitan Seattle
Site 2	St. Louis, Missouri; St. Thomas Aquinas High School
Site 3	New Orleans, Louisiana; Ochsner Foundation Hospital

Data obtained at the selected sites prior to the field inspections are given in Appendix C.

Excavations were made as follows: 4 at Seattle, 4 at New Orleans and 10 at St. Louis. Locations of excavations are shown on plot plans in Appendix D. Visual observations and photographs were made prior to removal of Foamglas and after sections of the Foamglas were removed. Photographs taken by NCEL personnel are presented in Appendix E (Figures E-1 through E-9).

Laboratory analyses were performed on the following: (1) soil samples from each excavation, (2) samples of Foamglas from each of the three sites, and (3) samples of ground water from Seattle and New Orleans. No ground water was encountered at St. Louis.

Pipe-to-soil electrical potential measurements were obtained at each excavation. These measurements were taken by means of a copper - copper sulfate reference electrode, which was placed first in the soil directly over the underground pipe and then in the soil 25 feet laterally away from the pipe. The reference electrode was directly connected to the hot pipe at each excavation.

Soil resistivity measurements were obtained immediately adjacent to each excavation. Measurements were taken to determine the average resistivity of the soil between grade and depths of 5 feet and 10 feet.

Laboratory tests of soil, ground water, and Foamglas were made by Twining Laboratories of Southern California, Inc., Long Beach, California. Moisture content of soil and Foamglas samples was determined.

Results and Discussion. At the time of the excavations, the water table was below pipe depth at Seattle, well below pipe depth at St. Louis, and above pipe depth at New Orleans. Excavations were made at Seattle at the beginning of the rainy season after a very dry summer. Operating personnel reported that the water table rises above pipe depth during the winter rainy season. The water table at St. Louis varies, and excavations were performed during a relatively dry autumn season. The water table at New Orleans, controlled by the adjacent Mississippi River, was reported to be essentially constant.

Installation techniques were somewhat different at each of the three sites. Factory-wrapped Foamglas (1-1/2 inches thick) with a moderately thin mastic covering and native backfill had been used at Seattle. Factory-wrapped Foamglas (1 inch thick) with very thin mastic covering and native backfill had been used in St. Louis. Foamglas (1-1/2 inches thick) covered with pipeline felt and native backfill had been used in New Orleans. In addition, a gravel bed, sump, and sump pump had been installed in New Orleans in an attempt to dewater the soil surrounding the Foamglas. All systems were essentially the same age, having been installed in 1957 and 1958.

Of the three systems, the Foamglas was in the best condition in Seattle and in the worst condition in New Orleans (see Appendix E for illustrations). Most of the Foamglas in Seattle was relatively intact, but there were isolated broken areas through which ground water had intruded to the pipe. At St. Louis, Foamglas had severely abraded because of pipe movement, and was badly broken up at most excavations. Water had intruded through the Foamglas to the pipe. At New Orleans the Foamglas system had been shut down and disconnected for approximately 2 weeks. The Foamglas at that site was relatively intact on portions of the condensate line but was completely disintegrated inside the pipeline felt along portions of the steam line.

At Seattle there was very little corrosion damage to the pipes. At St. Louis there was severe general corrosion damage on the original steel pipe. At New Orleans there was very little corrosion damage of either the steam or condensate lines.

Sections of Foamglas removed from the pipes in Seattle were found to be dry and similar in weight to samples of unused Foamglas. At New Orleans the pipelines were not hot and sections removed intact were found to be extremely heavy, indicating that they had absorbed water. At St. Louis pieces of Foamglas removed from the hot pipes at some excavations were found to be relatively heavy and steamy.

The results of soil and ground water tests are summarized in the following table:

Item	City		
	Seattle	St. Louis	New Orleans
Pipe-to-soil potential	Normal	Normal	Higher than normal
Soil resistivity	High (non-corrosive)	Low (corrosive)	Low (corrosive)
Soil analysis	Low in dissolved solids and chlorides; relatively neutral, low in conductivity	Same	Same
Ground water	Ground water obtained well below pipe depth	No ground water encountered	High in dissolved solids; high in chlorides; relatively neutral; high in conductivity

The contractor did not correlate Foamglas failures with the results presented in the above table. This is understandable when the following points are considered:

1. The vapor barrier covering the Foamglas is the only part of the piping system which is in direct contact with the soil, and the soil analyses did not reveal any unusual properties which would account for failures of the vapor barrier. Failures were usually attributed to stones, careless workmanship, and insufficient mastic.

2. The hot pipe is isolated from the soil environment unless water or water vapor penetrates the outer coating and Foamglas. Such penetration was reported at all three excavation sites but the ground water tests were not significant because no ground water was encountered near the pipeline at Seattle or St. Louis at the time of inspection.

3. At St. Louis, where soil resistivity indicated a corrosive soil, the pipe corrosion was severe; but at New Orleans, where soil resistivity also indicated a corrosive soil, the pipe corrosion was only slight — even on the cooler condensate lines.

4. The failure at New Orleans was characterized by disintegration of the Foamglas; this did not occur at the other two sites. This disintegration probably resulted from pressures exerted by external steam which was generated when water intrusion reached the outer surface of the pipe. As mentioned previously, water intrusion could not be attributed to soil properties.

In summary, the soil and water tests could not be correlated with Foamglas failures.

Foamglas absorption tests conducted by the Twining Laboratories are somewhat more severe than the ASTM method which is used by the manufacturer. Results of the method used by Twining Laboratories indicate that moisture absorption of Foamglas varied from 4.4% to 7.9% by volume. The manufacturer reported 0.2% absorption by volume using the ASTM method.

FINDINGS

1. High water table and moist soil constitute an adverse environment for Foamglas.

2. Laboratory experiments indicated that even new Foamglas can absorb water in amounts ranging up to 7.9% of its volume. The maximum absorption listed by the manufacturer is 0.2% by volume.

3. Since Foamglas is not impervious to water, the vapor barrier is the critical part of Foamglas installations.

4. Vapor barriers on pipes investigated were far from perfect. Breaks in the outer coating were attributed to stones, careless workmanship and insufficient mastic. Frequently, the cause was not apparent.

5. On systems operating at temperatures below the boiling point of water, the most serious problem resulting from Foamglas failure was pipe corrosion.

6. On systems operating at temperatures above the boiling point of water, the most serious problem resulting from Foamglas failure was heat loss. Water flashing into steam at the pipe surface apparently fractures the Foamglas and aggravates the heat-loss problem.

7. Few failures or complaints were reported where Foamglas installations were in a dry environment.

8. Where Foamglas was not uniformly supported by the soil, longitudinal movement of the pipe abraded the interior surface of the Foamglas and reduced its insulating effectiveness.

9. Although the manufacturer has a recommended installation procedure, the manufacturer's representatives do not always follow this procedure.

10. Data collected on pipe-to-soil potential, soil resistivity and soil analyses could not be correlated with failures in the Foamglas systems at the corresponding locations.

CONCLUSIONS

1. In a dry, underground environment Foamglas installations are satisfactory.

2. It is probable that in any underground environment, Foamglas systems could be installed which would be free from operating problems caused by defects, but the extreme care which would be required for such installations appears to make their use impractical. Therefore, Foamglas is not considered suitable for hot pipes installed below the water table or in soils with a high moisture content.

RECOMMENDATIONS

1. The use of Foamglas should be permitted in dry, underground environments (type B sites); however, the Foamglas must be installed in strict accordance with the manufacturer's recommended procedure.

2. Hot pipes should be located above ground where practical.

ACKNOWLEDGMENTS

The author wishes to acknowledge the work done by NCEL engineers who participated in the work reported here. Mr. R. J. Zablodil conducted the preliminary on-site visits. Mr. J. Andon carried out the preliminary telephone survey, served as task engineer during contract negotiations, and represented NCEL during the field inspection in Seattle. Mr. R. S. Chapler represented NCEL at the field inspection in St. Louis, and Mr. E. H. Wolff represented NCEL at the field inspection in New Orleans.

Appendix A

RESULTS OF PRELIMINARY TELEPHONE SURVEY

Minneapolis Airport Commission
Minneapolis, Minnesota

Fluid: steam (300°F)

Length: 700 feet of 10-inch pipe

Water table: unknown, but soil moisture high during rainy season

Age: 3-1/2 years

Remarks: no maintenance required

Northern States Power Company
Grand Forks, North Dakota

Fluid: steam (300°F)

Length: unknown

Water table: unknown but soil moisture quite high

Age: 11 years

Remarks: no maintenance required; pipes installed under pavement

Duluth Steam Company
Duluth, Minnesota

Fluid: steam (300°F)

Length: 9 miles

Water table: well below pipeline

Age: 16 years

Remarks: no maintenance required but condition of system unknown

National Distillers Product Corporation
Cincinnati, Ohio

Fluid: distillate

Length: 100 feet

Water table: always below pipe

Age: 6 years

Remarks: no maintenance required but condition of system unknown

International Business Machines
San Jose, California

Fluid: hot water

Length: 700 feet

Water table: always below the pipe and moisture content is low

Age: 2 years

Remarks: no maintenance

Treasure Island
U.S. Navy
San Francisco, California

Fluid: steam (310°F)

Length: 2,400 feet

Water table: always below the pipe

Age: over 5 years

Remarks: no maintenance required but condition of the system is unknown

Friden Calculator Company
San Leandro, California

Fluid: hot water (115°F)

Length: unknown

Water table: always below pipes

Age: not available

Remarks: no problems with Foamglas; pipes are installed under pavement

Merced General Hospital
Merced, California

Fluid: steam (345°F)

Length: 400 to 500 feet of 2-1/2-inch pipe

Water table: rises above pipe during winter rains

Age: 4-1/2 years

Remarks: no maintenance required; a section of the pipe recently examined was in excellent condition

Boston Edison Company
Boston, Massachusetts

Fluid: fuel oil (150°F)

Length: unknown

Water table: always below the pipe

Age: 3 years

Remarks: repairs made on the line at three different locations; Foamglas reportedly crumbled when the surrounding earth was removed

Boston Naval Shipyard
Boston, Massachusetts

Fluid: steam (380°F)

Length: 300 feet

Water table: during high tides the lines are probably under the tide level and are flooded

Age: 175 feet installed in 1959
40 feet installed in 1961
125 feet installed in 1963

Remarks: no maintenance problems; all lines are under pavement; Foamglas is considered expensive

From the following contacts no significant information was obtained:

Wesson Oil Company, Westwego, Louisiana

U. S. Navy, NAS, Pensacola, Florida

U. S. Navy, New Orleans, Louisiana

Louisiana Polytechnic Institute, Ruston, Louisiana

Virginia Light and Power Company, Virginia, Minnesota

Formica Company, Evendale, Ohio

International Paper Company, Mason, Ohio

Holiday Inn (two locations), Cincinnati, Ohio

Campbell School, Campbell, California

Foothill College, San Jose, California

General Electric Company, Evendale, Ohio

Lockheed-Georgia Company, Marietta, Georgia

Oxford Paper Company, Rumford, Maine

Appendix B

FOAMGLAS USERS CONTACTED IN FINAL TELEPHONE SURVEY

(See Reference 3 for details.)

Washington Wilkes High School, Washington, Georgia

Pearl Elementary and High School, Madison, Georgia

Jackson Elementary and High School, Jackson, Georgia

Cuthbert Elementary and High School, Cuthbert, Georgia

Tennille Elementary School, Summerville, Georgia

Dublin High School, Dublin, Georgia

Lyons Elementary and Toombs Central Schools, Lyons, Georgia

Braxton Elementary and High School, Douglas, Georgia

Homerville Negro High and Elementary School and Homerville White Elementary School, Homerville, Georgia

Murden School, Crawfordville, Georgia

College Site, College of Holy Names, Oakland, California

McLaughlin Jr. High School, Vancouver, Washington

Ivanhoe Elementary School, Bellville, Washington

Paine Air Force Base, Seattle, Washington

Lake City Sewage Treatment Plant, Seattle, Washington

Hospital Site, Northwest Memorial Hospital, Seattle, Washington

Colton High School, Colton, Oregon

St. Thomas Aquinas High School, St. Louis, Missouri

Northwestern University, Evanston, Illinois

Lutheran Seminary, Columbia, South Carolina

Abbeville County School District, Abbeville, South Carolina

University of South Carolina, Columbia, South Carolina

Paducah Housing Commission, Paducah, Kentucky

U. S. Army Redstone Arsenal, Huntsville, Alabama

Birmingham Housing Authority, Birmingham, Alabama

Valdosta State Teachers College, Valdosta, Georgia

University of Florida, Gainsville, Florida

Ochsner Foundation Hospital, New Orleans, Louisiana

Louisiana State Hospital, Jackson, Louisiana

Jackson Coliseum, Jackson, Mississippi

Texas A and M, College Station, Texas

Trinity College, San Antonio, Texas

Bel-Aire School, Tiburon, California

Del Mar Elementary School, Tiburon, California

College of San Mateo, San Mateo, California

Newport Hills Elementary School, Bellville, Washington

Raleigh Scholls Apartments, Seattle, Washington

Diagonal Sewage Treatment Plant, Seattle, Washington

Oregon Technical Institute, Inclement Falls, Oregon

Skidmore College, Saratoga Springs, New York

Corn Products Company, Argo, Illinois

Parkhill Nursing Home, Chillicothe, Illinois

Hopedale Medical Complex Hospital, Hopedale, Illinois

Caterpillar Company, Decatur, Illinois

University of South Florida, Tampa, Florida

Loyola University, New Orleans, Louisiana

Tulane University, New Orleans, Louisiana

University of Mississippi, Oxford, Mississippi

Norco Refinery, Shell Oil Company, Norco, Louisiana

General American Tank Storage, Good Hope Plant, Good Hope, Louisiana

NE Louisiana State College, Monroe, Louisiana

Texas Southern University, Houston, Texas

Rice Institute, Houston, Texas

Tomball Gas Plant, Humble Oil Company, Houston, Texas

Arlington State College, Arlington, Texas

North Texas University, Danton, Texas

Thermal Systems, Inc., Houston (Nassau Bay), Texas

Ampex Corporation, Redwood City, California

Appendix C

DATA ON FOAMGLAS COVERED PIPELINES SELECTED FOR INSPECTION

Site 1 — Municipality of metropolitan Seattle

Insulation:	1-inch-thick Foamglas finished with glass fabric and mastic
Pipeline use:	Recirculating hot water; system in continuous use
Pipeline:	300-foot run of two parallel 3-inch pipes from main plant building to service building
Fluid carried:	Hot water, 200°F, 30 psig
Installation date:	1958
Site description:	Low lying flat area; pipe is located under gravel service road
Depth of water table:	Five feet below grade during summer dry season, but much higher (around pipes) during winter rainy season
Soil:	Soil is fill material described as clay, sand, and rock. Soil moisture is high, but is reported to be relatively noncorrosive to underground pipes
Maintenance problems:	Mechanical break in a pipe was reported to have occurred a few years ago as a result of ground settlement. Pipe was recovered with Foamglas by plant maintenance forces. No moisture was found inside Foamglas
System efficiency:	Operators feel that system is fairly efficient, having only a 10°F drop in entire recirculating system. However, no checks are made specifically on the underground portion. Snow melting over the pipe route indicates there is some underground heat loss. This system is oil fired; it is reported that fuel-oil consumption has not risen through the years

Site 2 — St. Thomas Aquinas High School

Insulation:	1-inch-thick Foamglas; material was visually observed in excavation to have one layer of glass fabric. However, no mastic could be seen and there were no steel bands around Foamglas. Backfill material was native soil around Foamglas

Pipeline use:	Recirculating hot water heating for campus buildings; system is shut down during summer
Pipeline:	1,150-foot run of 2-inch to 8-inch schedule 40 steel pipe; a monoflow system with main loop around campus quad and service loops running under slab buildings; approximately 1,800 feet of pipe in 1,150-foot run since service loops contain two parallel pipes; no expansion loops provided, but there are many turns in system; pipes buried approximately 4 feet deep
Fluid carried:	Hot water, 200°F, low pressure; water is treated to limit internal corrosion
Installation date:	1957-58
Site description:	Rolling countryside in suburban St. Louis; pipe is located primarily under lawns that are well maintained
Depth of water table:	Water table is not known, but is below pipe; however, soil is relatively moist
Soil:	Soil is clay and is moist; area is subject to considerable precipitation; soil is corrosive, having an average resistivity of approximately 2,000 ohm-cm. Corrosion failures had occurred on the heating pipes and gas pipes
Maintenance problems:	Three major failures have occurred in underground heating lines. First failure was in 1961 and required replacement of 90 feet of 8-inch pipe with 6-inch copper pipe. Second failure involved a considerable amount of 2-inch pipe. Third failure involved a 200-foot run of 2-inch to 4-inch parallel steel pipes. All corrosion has been severe general external corrosion (no pitting) and water has been found inside Foamglas which was badly cracked. All repairs have been made with copper pipe coupled to the steel pipe with dielectric insulators. Failures have been located in three widely scattered points around campus.
System efficiency:	Heating system reported to be quite efficient with only a 7°F drop around entire loop including heating the buildings. Cost of heating has gradually risen, but the increase is thought to be the result of increased school enrollment. Makeup water is treated and an increase in cost of treatment chemicals was noted in 1961 at time of first failure. It was reported that snow melts over pipe, but steam does not rise after rain.

Site 3 — Ochsner Foundation Hospital

Insulation:	1-1/2-inch-thick Foamglas, finished with two layers of glass fabric, three layers of mastic and sand backfill; insulation was badly cracked on riser at main building
Pipeline use:	Process and heating; system is in constant use for hospital operation
Pipeline:	600-foot run of parallel 4-inch steam and 2-inch condensate pipe; pipe is steel, buried 2 feet deep and runs from main building to two small service buildings. There are approximately three 90 degree turns and slip type expansion joints at one turn.
Fluid carried:	Saturated steam 310°F, 60 psig; condensate at approximately 150°F
Installation date:	1958
Site description:	Low-lying flat area; pipe is located under lawn, crosses two paved service roads and paved parking area
Depth of water table:	18 to 24 inches
Soil:	Sandy loam and blue clay saturated with water; soil corrosiveness is reported to be moderate
Maintenance problems:	Whole system was reworked 6 months after installation because of water getting inside insulation and steam rising from wet ground. A 1-foot-thick gravel bed was installed under the pipeline and connected to a dry well and sump pump. This was an attempt to lower the water table around the pipe. Apparently this was moderately successful for a while, but the situation gradually worsened, with more and more steam rising from wet ground. The system was abandoned in 1965 and replaced with a metal conduit system.

Appendix D

FIELD INSPECTION PLOT PLANS

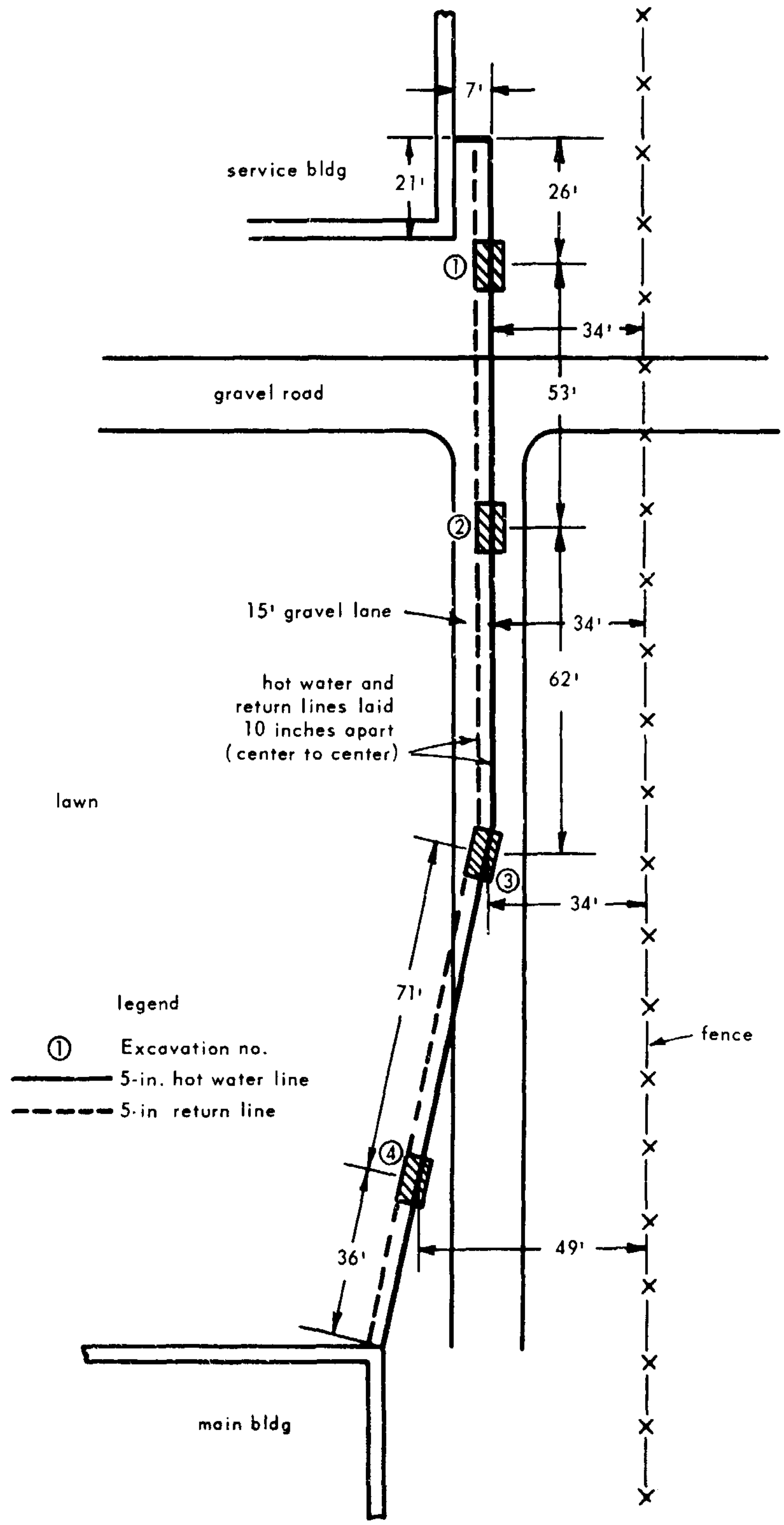

Figure D-1. Plan view: location of underground hot water pipes, Lake City Sewage Plant, Municipality of Metropolitan Seattle, Washington.

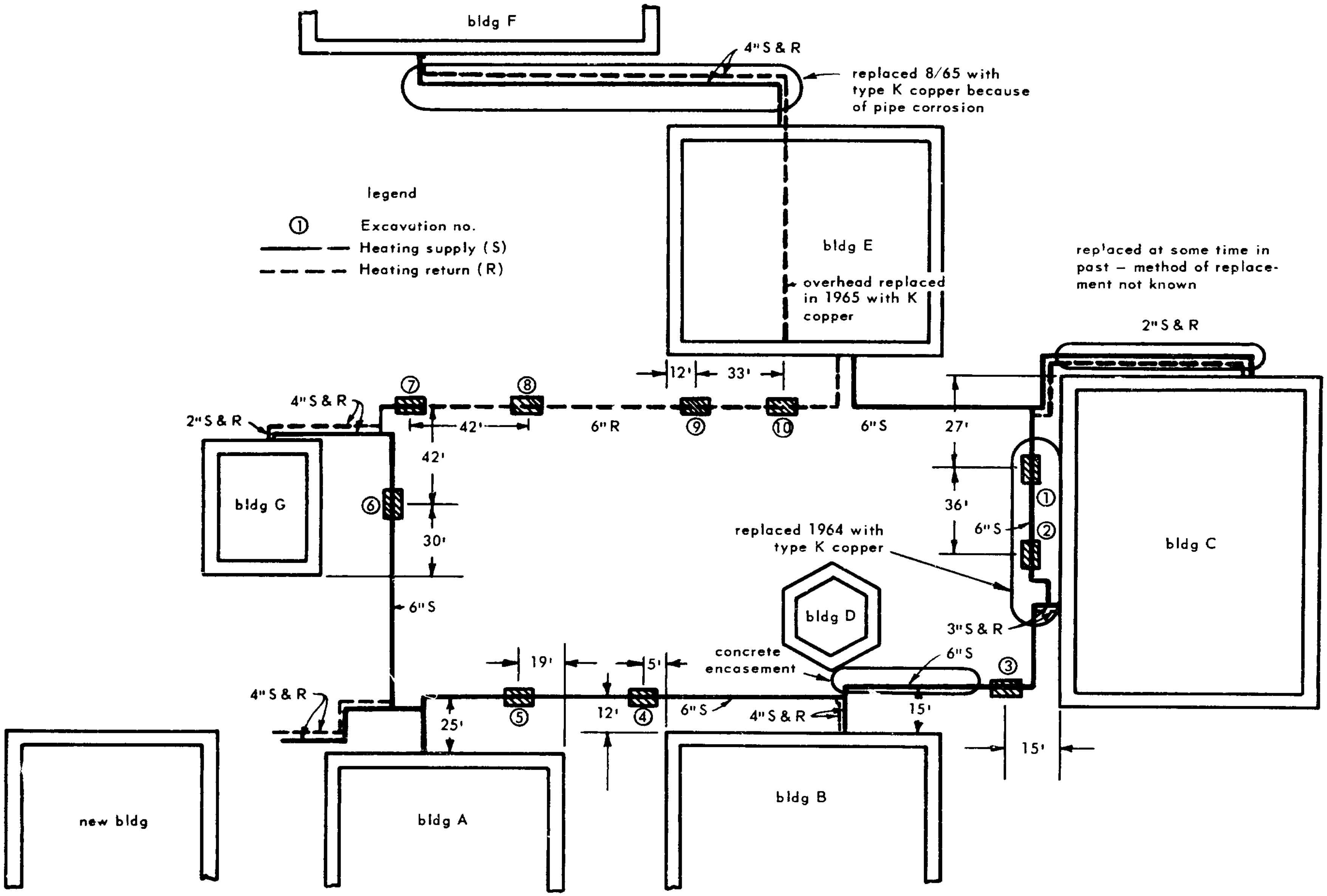

Figure D-2. Plan view: location of underground hot water heating system, St. Thomas Aquinas High School, St. Louis, Missouri.

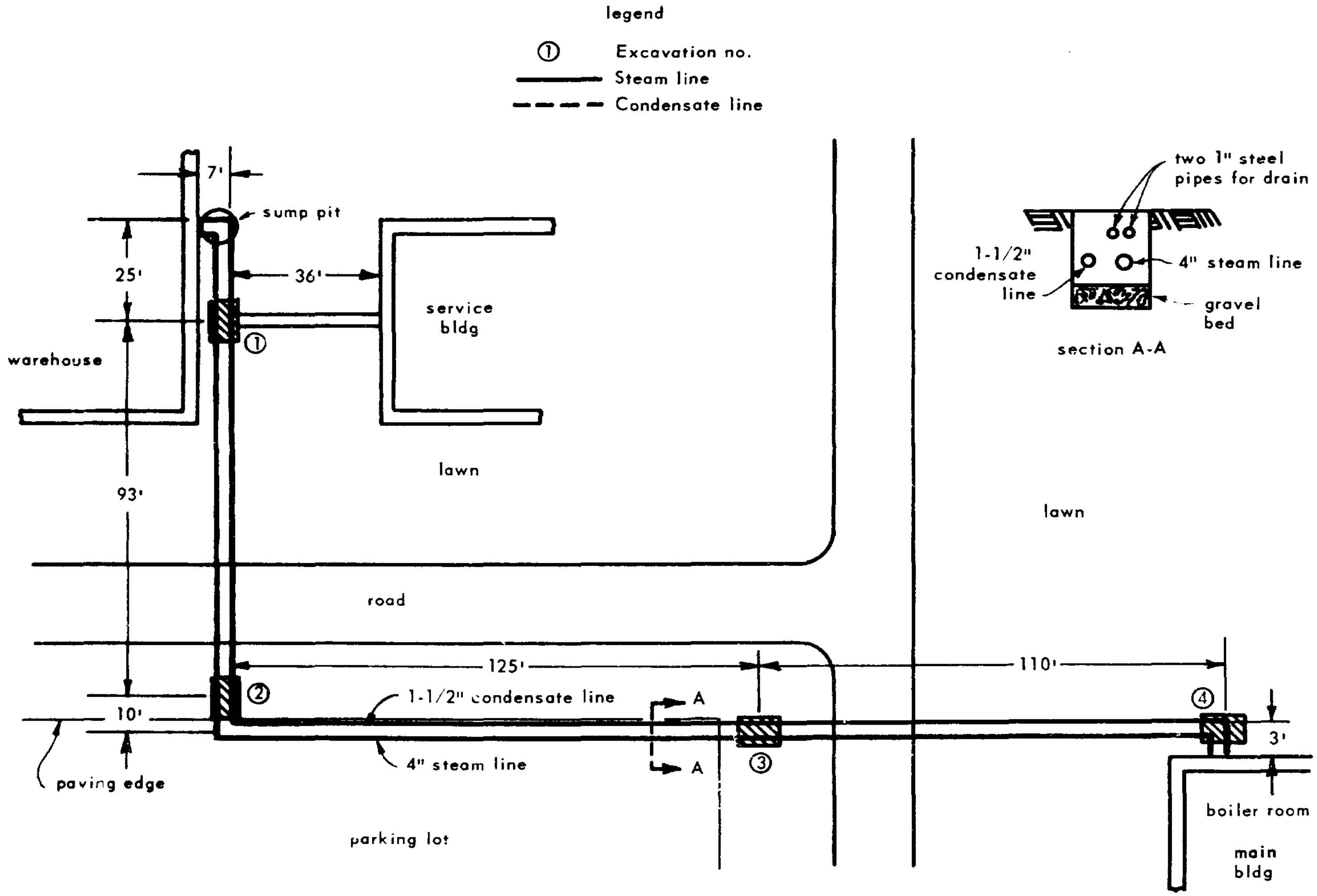

Figure D-3. Plan view: location of underground steam and condensate pipes, Ochsner Foundation Hospital, New Orleans, Louisiana.

Appendix E

PHOTOGRAPHS OF FOAMGLAS-COVERED PIPES IN SITU

Figure E-1. Seattle. The insulation has been removed from the pipe revealing that both pipe and insulation are in good condition.

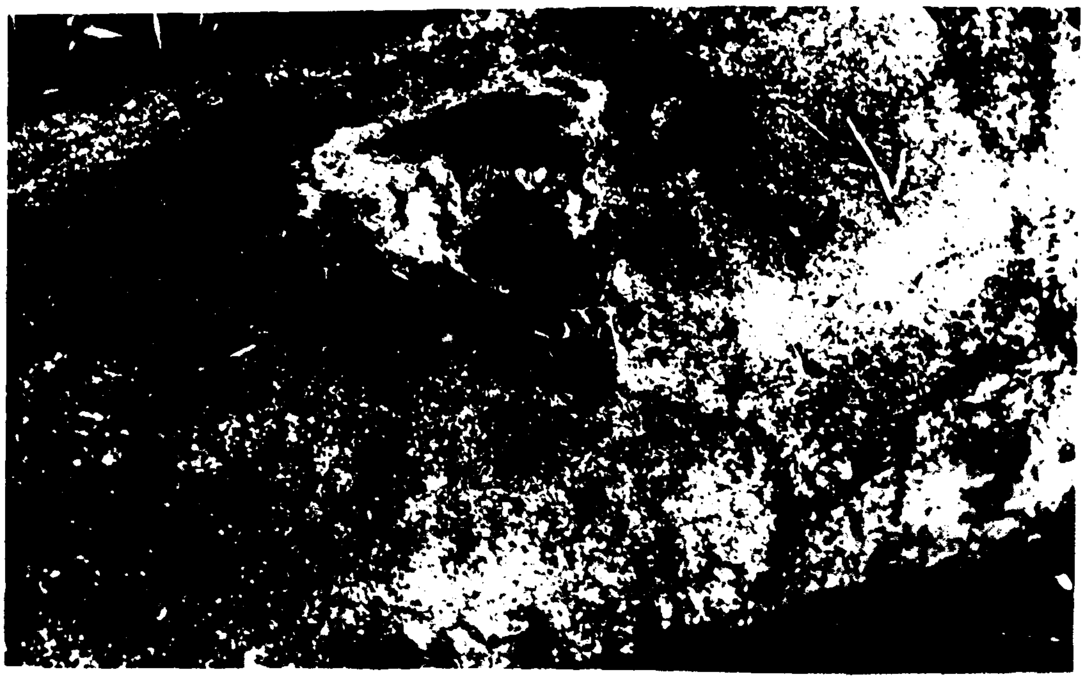

Figure E-2. Seattle. An example of mechanical damage; although the Foamglas was punctured to the pipe surface, there was no evidence of pipe corrosion.

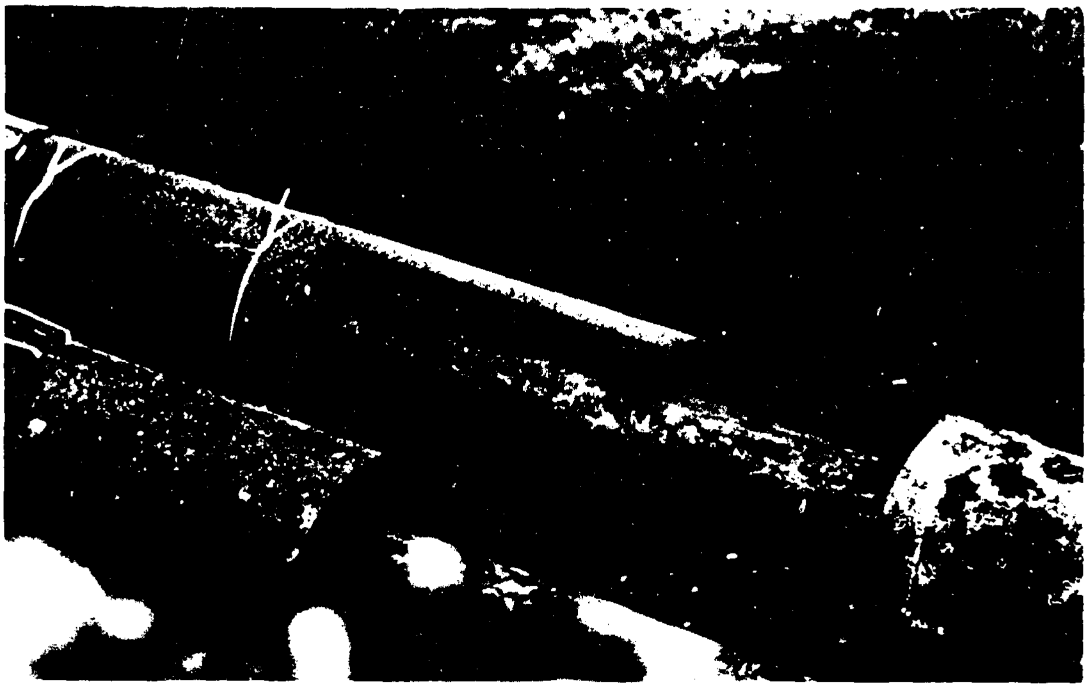

Figure E-3. Seattle. The pipe is being recovered with half sections of Foamglas which are being secured to the pipe with stainless steel wire.

Figure E-4. Seattle. A layer of mastic is being properly applied to the Foamglas by gloving. (Compare with Figure E-5 in which mastic is being improperly applied.)

Figure E-5. St. Louis. Coating new Foamglas section with mastic; contractor thinned mastic with gasoline so that it could be applied with brush, thus ignoring Foamglas Manufacturer's recommendation that mastic be gloved on.

Figure E-6. St. Louis. Building rubble such as this found in backfill causes damage to Foamglas.

Figure E-7. St. Louis. Section of Foamglas shows breakage and thinning of upper portion presumably due to abrasion from the inside.

Figure E-8. New Orleans. Typical excavation before pumping. The distance from water to grade was 2 to 3 feet.

Figure E-9. New Orleans. Typical excavation after water was pumped from the hole. Note condition of Foamglas on condensate line.

REFERENCES

1. U. S. Naval Civil Engineering Laboratory. Technical Note N-467: Cellular glass insulation for underground hot lines, by R. J. Zablodil. Port Hueneme, Calif., Oct. 1962.

2.———. Technical Note N-681: Foamglas insulation for buried hot pipelines, by R. J. Zablodil. Port Hueneme, Calif., Jan. 1965.

3. Harco Corporation. Report on Contract No. NBy-62177: Survey of Foamglas insulated buried hot pipelines, Phase I. Hawthorne, Calif., July 1965.

4.———. Report on Contract No. NBy-62177: Survey of Foamglas insulated buried hot pipelines, Phase II. Hawthorne, Calif., Sept. 1965.

5.———. Report on Contract No. NBy-62177: Survey of Foamglas insulated buried hot pipelines, Phase III. Hawthorne, Calif., Nov. 1965.

6.———. Report on Contract No. NBy-62177: Survey of Foamglas, Phase III, photographs of excavations. Hawthorne, Calif., Nov. 1965.

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